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Van Oudheusden, Rosanne

Biologie

RAPPORT 73

RuG Wetenschapswinkel

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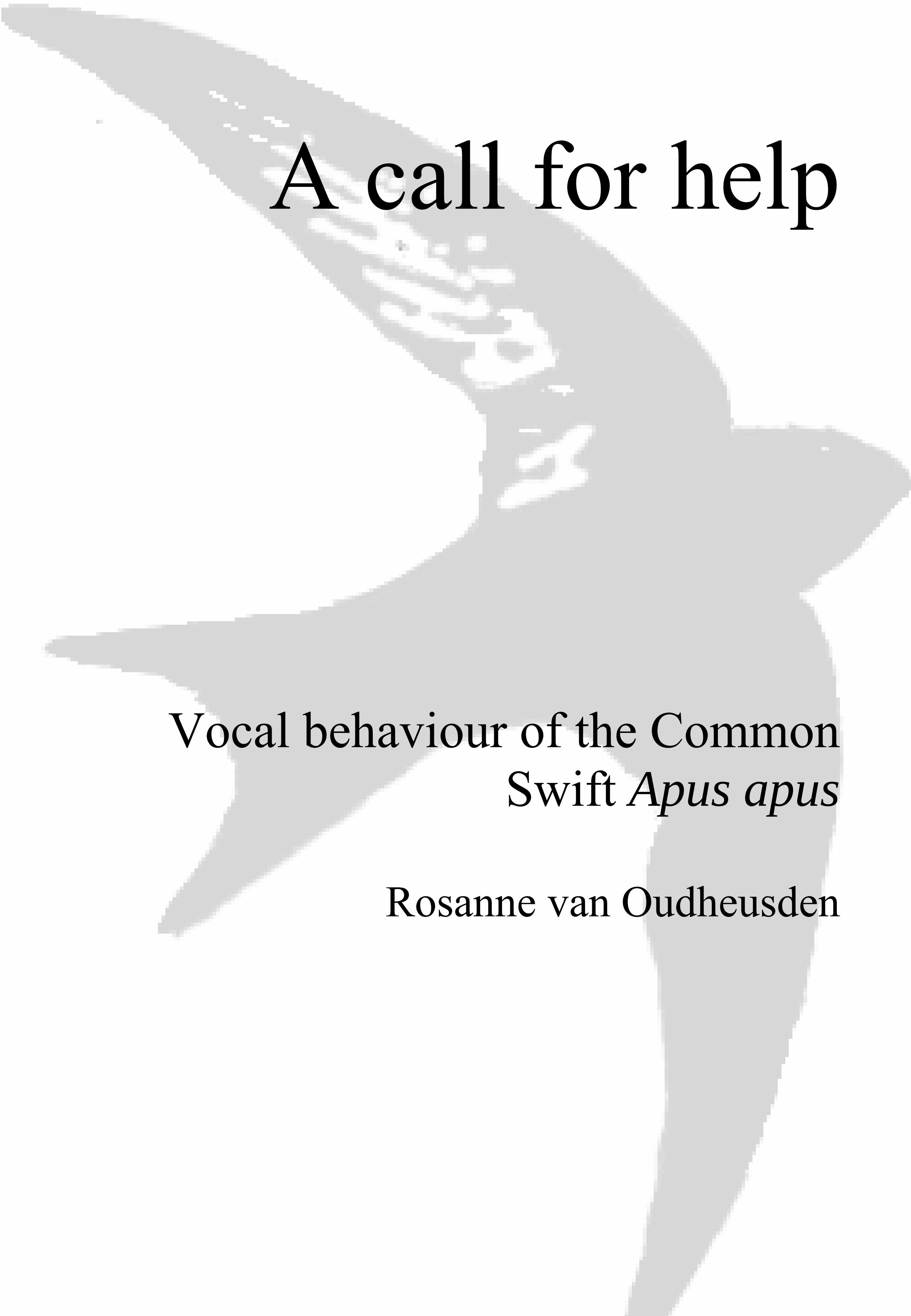
Haren, November 2006



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# Colophon

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ISBN 90 367 2517 8

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# Preface

## About GBN

The Dutch Foundation for the Protection of the Common Swift (GierzwaluwBescherming Nederland; GBN), founded on June 22nd, 2002, seeks to protect the Common Swift.. Due to urban renovation, these colonial breeders are rapidly losing a substantial part of their traditional nesting places. According to GBN, the birds are not particularly quick to occupy nest boxes which are offered by GBN to compensate for this loss.
Like many bird protection organizations, GBN has a lot of expertise on ‘their’ species, expertise which they continually seek to improve. They observe breeding birds with cameras; they share and conduct knowledge and information; they help to create new nesting places and they monitor the birds without disturbing them.
Throughout the Netherlands GBN has placed many nest boxes, but it takes some five or six years before the swifts will accept them as nesting space. GBN tries to lure the birds, by playing recordings of their calls. Their results show promise, but the method does not always seem to work. Therefore GBN has asked the Science Shop Biology in Groningen if it was possible to start a research project on the vocal behaviour of the Common Swift and improve methods to attract them by playing specific sounds.

## About this project

The project was advertised on the Science Shop’s website and Rosanne van Oudheusden, a student from Utrecht University applied. She had 7,5 months available in her educational program Expert supervision was found at the Leiden University at the department of Behavioural Biology and in the persons of Professor Carel ten Cate and Dr Hans Slabbekoorn. GBN volunteers assisted during the fieldwork. The idea was to develop the project so far, that GBN is enabled continue its data collecting for a couple of seasons, since it will take a series of breeding seasons to collect enough data for a reliable protocol.

## About the Science Shop

The Science Shop for Biology is part of the Biology Department of the University of Groningen. Science shops provide cheap or even free access to academic research, for civil groups or organizations in order to further their ends. Students can conduct such research r as a part of their training, by mediation of the Science Shop. If more extensive research than student's projects is required, the Science Shop can help fundraising.

## About the Department of Behavioural Biology, Leiden University

This group has large experience with the vocalization of birds and analysis of their meaning and function. The group combines research of proximate mechanisms and development of behavior (learning processes) with ultimate processes (adaptation and evolution). This may generate novel ideas about behavioral evolution and the role of behaviour in evolutionary processes. Bird vocalizations are an important model system in this research.

# Contents

# Summary


***The problem***

The Common Swift (*Apus apus*) is a bird well adapted to urban environments. They changed their natural nests in rocks and trees for places under the roofs of old buildings. A lot of these nesting places disappear, due to renovation and demolishment of the buildings. An alternative nesting place is not always available. There is reason for concern that this may reduce the densities of Common Swift populations in the Netherlands, turning it into an endangered species. The Dutch Foundation for the Protection of the Common swift (GBN) provides artificial nesting places to compensate for the loss of nests. But the occupation of these nests often takes up to several years, therefore a student research project was set up in collaboration with the Science Shop for Biology in Groningen and Behavioural Biology in Leiden, to explore the possibilities of attracting Common Swifts to artificial nesting places by playback of their sounds.

***Outline of this study***

Scientific experiments have demonstrated that colonial birds can be attracted by the use of playback, both in combination with other techniques, and used alone. There is already some basic knowledge about the sounds of the Common Swift, and given the fact that it is a colonial breeder, it is interesting to find out if they can be attracted to new nesting sites by using the playback of their sounds. As a first step it was thought necessary to classify and characterize the vocalizations of the birds.

Sounds of the Common Swift are made up of a screaming part and a trill part. A study by Bretagnolle (1993), which was used as a point of departure for this study, distinguished three different calls: Long Screaming Call, Duet Screaming Call and Nest Call.

The first part of this study describes which different calls the Common Swift produces. Recordings in the field were taken at different locations from both individuals as colonies. In the analysis different call parameters (e.g. Total Duration of the Call, Peak Frequency Averaged over the whole Call) were measured en differences between individuals and locations were explored. The findings were compared to previous studies. The second part includes playback experiments with different sounds to study how the birds reacted vocally and behaviourally and whether they seemed to be attracted by the playback of specific sounds.

***Mapping the sounds***

Throughout the Netherlands recordings were made between June 16$^{th}$ and August 1$^{st}$ 2006. At 8 locations colony recordings and on 7 locations other recordings were made. Of these recordings colony and individual sounds were selected for use in playback experiments. On 5 locations such a playback experiment was performed. The call characteristics were analysed with the use of the *Avisoft* software. In total 11 temporal and frequency parameters were chosen for analysis.

Different calls were identified from their sonograms. Screaming calls were found over a broad range of Total Duration of the Call. There were also calls found without a trill part (peep calls). The categorization of Bretagnolle (1993) appeared difficult to follow, due to methodological problems. The inventory of calls could be improved by taking into account difference in context of behaviour (territorial behaviour/partner recognition) and environment (in the air/on the nest). Additional research is needed to study call parameters in order to make a classification of different calls. Individual recognition of birds is a problem that has to be addressed in future research too.

Also, the number of recordings was not high enough to test for differences between individuals. To explore the variation within and between individuals, 5 calls of a single individual were compared to 5 calls of different individuals of the same location. The variation for all measured parameters is small within the individual, compared to the variation between different individuals.

***Location-related differences***

To compare the differences between 6 locations, several analyses were made. In the first analysis, all calls were grouped together, regardless of their Total Duration of the Call. This showed that 4 parameters were significantly different between locations (Total Duration of the Call $p=0.033$; Interval between Screaming and Trill part $p=0.019$; Duration First Trill $p=0.006$; Peak Frequency First 20 ms $p=0.035$; $N=57$). In the second analysis the calls were split in groups based on their Total Duration of the Call. The group < 0.600 s had 2 significantly different parameters between locations: Interval between Screaming and Trill part ($p=0.048$) and Duration First Trill ($p=0.002$; $N=56$). There were no significant differences between locations for the group ≥ 0.600 s. ($N=13$).

Peep calls were analyzed as a different group, all 4 parameters were significantly different between locations (Total Duration of the Call $p=0.007$; Peak Frequency Averaged over the Whole Call $p=0.004$; Peak Frequency First 20 ms $p=0.002$; Fundamental Frequency $p=0.004$; $N=58$). More experiments are needed to explore if these differences are really caused by the different locations, or maybe by the difference between individuals or other factors. These differences can have influence on the use of calls during playback experiments.

***Playback results***

One playback experiment was used as a case study. After the playback of individual and colony sounds, the number of scored birds within a range of 10 metres from the source increase. The difference before and after playback was for the individual stimulus 2 to 120, compared to colony stimulus 15 to 26. During the control period (no sound) the number of birds decreased. The birds responded vocally to the playback of their calls.

***Concluding remarks***

In conclusion, different calls could be described, with and without a trill part. Variation within individuals is small, compared to the variation between different individuals. There is also variation between locations. Additional research is needed, especially repeated measurements on single individuals, to find out if the differences are really caused by the different locations, or by other factors. Playback of sounds of individuals seems to attract the birds, however more experiments are needed for statistical testing. Intensive research during the whole field season can help us to understand if specific playback of sounds can attract Common Swifts. Monitoring is needed to find out if the attraction of birds also leads to long-term nesting and breeding in artificial nesting places.

# Nederlandse Samenvatting

***Het probleem***

De gierzwaluw (*Apus apus*) heeft zijn natuurlijke nestplaatsen in rotsen en oude bomen maar is een veel voorkomende stedelijke soort die ook goed gedijt in nesten onder daken van oude gebouwen. Door de renovatie en sloop van deze gebouwen verdwijnen veel van deze nestplaatsen. Omdat er niet altijd alternatieve nestlocaties beschikbaar zijn, bestaat er onder vogelliefhebbers grote zorg over het voortbestaan van de gierzwaluw in Nederland. De mogelijkheid bestaat dat de gierzwaluw een bedreigde vogelsoort zou kunnen worden, daarom probeert GierzwaluwBescherming Nederland (GBN) de gierzwaluw op meerdere manieren te beschermen, o.a. door het plaatsen van nestkasten en nestpannen om de afname van natuurlijke nestplaatsen te compenseren. Aangezien de bezetting van deze kunstmatige nestplaatsen enkele jaren kan duren heeft GBN de Wetenschapswinkel Biologie in Groningen benaderd voor het initiëren van een onderzoek waarbij gekeken kon worden naar het lokken van gierzwaluwen naar nestkasten met behulp van het afspelen van geluid. Voor dit project werd een studente biologie aangetrokken en de vakgroep Gedragsbiologie van de Universiteit van Leiden werd benaderd voor de wetenschappelijke begeleiding. Als eerste stap was het nodig om de verschillende geluiden op te nemen en te karakteriseren.

***Opzet van dit onderzoek***

Uit wetenschappelijke experimenten is gebleken dat het afspelen van geluid (playback), al dan niet in combinatie met andere technieken, koloniale vogels kan aantrekken. Omdat er al enig kennis is over de geluiden van de koloniale gierzwaluw, lijkt dit een geschikt uitgangspunt om te onderzoeken of gierzwaluwen kunnen worden aangetrokken naar nieuwe nestplaatsen met behulp van vocale stimuli.Over geluiden van gierzwaluwen is bekend dat ze bestaan uit twee gedeelten: een 'screaming' (gil) gedeelte en een 'trill' (triller) gedeelte. Een studie van Bretagnolle uit 1993 wordt in dit onderzoek gebruikt als vertrekpunt. In deze studie worden drie soorten geluiden onderscheiden: een lange call (roep): Long Screaming Call; een kortere call, zowel in duet gegeven als zelfstandig (Duet Screaming Call) en een call gegeven op het nest (Nest Call).

In het eerste deel van dit onderzoek wordt beschreven welke verschillende geluiden de gierzwaluw produceert. Hiervoor werden opnames gemaakt op verschillende locaties, zowel van individuele vogels als van kolonies. In de analyse werden verschillende kenmerken (o.a. call duur, piekfrequentie) van de geluiden gemeten en gekeken of er verschillen waren tussen individuen en locaties. De bevindingen werden vergeleken met de uitkomsten van eerdere studies. In het tweede deel zijn playbackexperimenten gedaan met verschillende geluiden om te onderzoeken hoe de vogels daar in hun gedrag en vocaal op reageerden en of ze eventueel konden worden aangetrokken met het afspelen van specifieke geluiden.

***Geluiden in kaart brengen***

Verspreid over Nederland werden tussen 16 Juni en 1 Augustus 2006 op 15 verschillende locaties geluidsopnames gemaakt. Op 8 plaatsen werden geluiden van kolonies opgenomen en op 7 locaties andere opnames. Van deze opnames werden koloniegeluiden en individuele geluiden geselecteerd voor gebruik tijdens playback experimenten. Op 5 locaties werd een playback experiment gedaan. De kenmerken van de geluiden werden geanalyseerd met behulp van *Avisoft* software. Er werden 11 verschillende temporele- en frequentieparameters gekozen om te analyseren.

Er werden verschillen in de geluiden gevonden op basis van sonogrammen. Screaming calls werden gevonden met een brede range van totale duur van de call. Er werden ook geluiden gevonden zonder trill gedeelte (peep calls). De categorisatie zoals Bretagnolle (1993) beschreef bleek moeilijk te volgen vanwege methodische problemen. De indeling van geluiden kan beter gebaseerd worden op verschillen in context van gedrag (territoriaal gedrag/partnerherkenning) en omgeving (in de lucht/op het nest). Extra onderzoek is nodig voor het bestuderen van geluidskenmerken om een indeling van geluiden te kunnen maken. Een probleem hierbij is dat individuen onderling moeilijk te herkennen zijn. Voor het statistisch vergelijken van verschillen tussen individuen zijn te weinig opnames gemaakt. Om te onderzoeken hoe verschillen tussen individuen er uitzien, werden 5 geluiden van 1 individu vergeleken met 5 geluiden van verschillende individuen van dezelfde locatie. De variatie binnen 1 individu blijkt kleiner te zijn dan de variatie tussen verschillende individuen voor alle gemeten parameters.

***Verschillen tussen locaties***

Voor het vergelijken van geluiden tussen 6 locaties zijn er verschillende analyses gedaan. In de eerste analyse zijn alle geluiden ongeacht hun totale duur bij elkaar genomen. Hieruit bleek dat vier parameters statistisch verschillen (totale duur per call $p=0.033$; interval tussen screaming en trill part $p=0.019$; duur van eerste trill gedeelte $p=0.006$; piek frequentie van de eerste 20 ms $p=0.035$; $N=57$). In de tweede analyse zijn de geluiden in twee groepen gescheiden op basis van hun totale duur. Voor de groep van $<$ 0.600 s waren alleen het interval tussen screaming en trill part ($p=0.048$) en de duur van eerste trill gedeelte ($p=0.002$; $N=56$) significant verschillend tussen de locaties. Voor de groep van $\geq$ 0.600 s. zijn geen significante verschillen gevonden ($N=13$). Buiten deze twee analyses bleek voor de groep van de peep calls dat vier parameters significant verschillen tussen locaties (totale duur van de call $p=0.007$; piek frequentie over de hele call $p=0.004$; piek frequentie van de eerste 20 ms. $p=0.002$; fundamentele frequentie $p=0.004$; $N=58$). Meer experimenten zijn nodig om te onderzoeken of de gevonden verschillen inderdaad het gevolg zijn van verschillen tussen locaties, of misschien van verschillen tussen individuen en andere factoren. Deze verschillen kunnen van invloed zijn op welke geluiden het meest geschikt zijn om te gebruiken voor playback.

***Playback experimenten***

Een playback experiment werd gebruikt als case studie. Na het afspelen van kolonie en individuele geluiden nam het aantal vogels binnen 10 meter van de bron toe. De toename was het sterkst na het afspelen van individuele geluiden (2 voor, 120 na vergeleken met kolonie 15 voor, 26 na). Tijdens de controle periode (geen geluid) nam het aantal vogels af. Vogels reageerden vocaal op afgespeelde geluiden. Meer experimenten zijn nodig voor statistisch testen.

***Conclusie***

Er konden dus meerdere gierzwaluwgeluiden worden onderscheiden, zowel met als zonder trill-gedeelte. Er is weinig variatie in geluiden binnen individuen vergeleken met meerdere individuen, maar er is juist wel variatie tussen locaties. Verder onderzoek, vooral herhaalde waarnemingen aan individuen, zullen moeten uitwijzen of de gevonden verschillen werkelijk door verschil in locatie veroorzaakt worden, of door andere factoren. Het afspelen van individuele geluiden lijkt de vogels aan te trekken.

Intensief onderzoek gedurende het hele veldseizoen kan ons helpen te begrijpen of het afspelen van (specifieke) geluiden gierzwaluwen kan lokken naar kunstmatige nestplaatsen en er ook daadwerkelijk voor kan zorgen dat de vogels gaan nestelen en broeden op de lange termijn.

# 1. Introduction

## 1.1 Concern for the Common Swift

The Common Swift (*Apus apus*) is a species that seems to have adapted surprisingly well to the man-made urban environment. They left their natural nests in rocks and trees for cracks in walls and under tiles of roofs of old buildings. However, with restoration or demolition of old buildings and their roofs, there is huge annual loss of these nesting sites. There is reason for concern that this may severely reduce densities of Common Swift populations, turning it into an endangered species. To compensate for the loss of nests, the Dutch Foundation for the Protection of the Common Swift (GBN) provides artificial nest-boxes and nest-tiles. But the birds seem to have trouble in finding and occupying these nests. The volunteers of GBN try to lure the birds by playing recordings of their calls. They seek to improve their methods and asked the Science Shop for Biology for scientific support. In collaboration with the Behavioural Biology research group in Leiden, a student research project of 7,5 months was set up to explore the possibilities of attracting Common Swifts to artificial nesting places by the playback of their sounds.

## 1.2 Using sound for bird attraction

Efforts to conserve endangered bird species include strategies to lure the birds to (new) safe nesting sites, where it can breed without disturbance. Many colonial breeders have the tendency to settle near to one another: they exhibit conspecific attraction (Smith and Peacock, 1990; Ward and Schlossberg, 2004). Conspecifics can be indicators of habitat quality, or they might intrinsically affect reproductive success. Birds may use the presence of conspecifics as cues to establish breeding and feeding territories (Reed and Dobson, 1993).

Experiments with (sea) birds show several ways to attract birds to nesting sites. Active replacement of chicks, the positioning of wooden puffin decoys and gull-control were used to re-establish Atlantic Puffins at a former breeding site in the Gulf of Maine (Kress and Nettleship 1988). The use of decoy models attracted endangered New Zealand Fairy Terns to habitats (Jeffries and Brunton, 2001). Artificial Albatross models, combined with vocal stimuli were used to attract Laysan Albatross to areas on the island of Kauai (Podolsky, 1990). A package of measures, including creation of new nesting habitat, social attraction techniques (including vocal playback), predator control and discouraging to breed at the old location, led to the complete relocation of a colony of Caspian Terns in Oregon (Roby et al., 2002). Chick transfers and acoustic attraction established a colony of Common Diving Petrels on Mana Island (Miskelly and Taylor, 2004). By playing their vocalizations, Leach’s Storm Petrels tended to colonize burrows close to the speakers in Maine (Podolsky and Kress, 1989). The playback of vocalizations attracted endangered Dark-rumped Petrels in the Galapagos Islands (Podolsky and Kress, 1992). By playing vocalizations, the Black-capped Vireo, an endangered territorial songbird, was also attracted to unoccupied habitats in Texas; so not only birds who breed in groups show conspecific attraction (Ward and Schlossberg, 2004).

Thus, playback of vocalizations, both in combination with other techniques and used alone, seems to be an effective means to attract (colonial) birds. Although it is not always clear how these kinds of experiments contribute to the long-term conservation of endangered species, monitoring of these populations over a longer period of time can tell us if the effects of attraction are more than just short-term reactions.
Because of the concern for a severe decline of Common Swift populations, GBN intends to attract the birds to artificial nesting places. As mentioned above, the use of vocal stimuli is a suitable approach. There is already some basic knowledge about the calls of the Common Swift, and with the knowledge that Common Swifts are colonial breeders, it is interesting to find out if they can be attracted to new nesting sites by using vocal stimuli, e.g. the playback of their calls. But they want to set up a good program, based on the best available information and including a protocol for monitoring the results, with a minimum of disturbance to the birds.

## 1.3 Background information on the Common Swift

Common Swifts (*Apus apus*) belong to the order Apodiformes, family Apodidae, which means 'no legs'. Common Swifts do have legs, but they are only used for clinging against walls and vertical objects. Walking is very difficult; they can only crawl a little bit on the nests. Therefore, Common Swifts spend most of their life up in the air. They are amazing flyers. They migrate every year to Africa, below the equator, a distance of 7000 kilometres. They can reach up a speed of 120 km/h. With a body length of 16-17 cm and a wingspan of 38-40 cm, this is a quite an accomplishment. Common Swifts are blackish brown, with a whitish throat: it is a monomorphic species, male and female cannot be distinguished from one another. They feed on flying insects and spiders (up to 20.000 a day).
The Common Swift spends about three months in the Netherlands. They arrive at the end of April/the beginning of May and they leave at the end of July/the beginning of August. Therefore, they are also called the 'hundred days bird'; this is approximately the time they stay in their breeding area. The Common Swift is a monogamous seasonally paired bird. They lay two to three white eggs of approximately 3,5 grams. Both parents breed for 19-20 days. The young are ready to fly when their wings are 16 cm long (± 40 days after hatching). Common Swifts can reach an average age of seven years (CS, 2006).

Several features of the Common Swift are studied quite intensively e.g. breeding biology (Dell'omo et al. 1998; Lotem, 1998); fledging (Martins, 1997); aerial roosting (Tarburton, M.K. and Kaiser, E., 2001); leading-edge vortex (Müller and Lentink, 2004, Videler et al., 2004). However, the vocal behavior has received little attention thus far.

## 1.4 Vocal behavior of the Common Swift

The first descriptions of the calls of the Common Swift were of an onomatopoeic nature: 'shrill scream', 'swee-ree'call (two notes, one given by each member of the pair), 'plaintive piping' call (given in later stages of fights), 'high-pitched scream', (Lack, 1950). Looking at the sonograms, Malacarne et al. (1989), gave the description of a 'bell-shaped' Common Swift call. According to Bretagnolle (1993), Cramp (1985) defined the most commonly used call of the Common Swift as 'the screaming call', given both at the nest and in flight. Bretagnolle (1993) stated that “the screaming call consisted more of a family of highly variable calls, rather than being a call itself”. He distinguished three different calls, on the basis of their sonograms. The Long Screaming Call (LSC), a single call given in a long version. The second call was the Duet Screaming Call (DSC), a single call given in a short duration, given in duet (defined by Malacarne and Cucco (1990) as ‘antiphonal song’) or not. The third call was already described by Cramp and given the name Nest Call (NC).

According to Bretagnolle (1993) the screaming call can always be divided in a screaming part and a trill part. The screaming part has two basic acoustic features: it’s fundamental frequency lies around 2500 Hz. Often, the fundamental frequency can not be detected on the sonogram and the first harmonic is displayed, which lies around 5000-6000 Hz. (In this study the fundamental frequency could occasionally be detected on the sonogram. It is however not clear if this is the fundamental frequency or an alteration of the sound). The second characteristic is that on the fundamental frequency there is an amplitude modulation at ca. 200 Hz, which explains the clicking or pulsating sound of Common Swift calls. The trill part consists a number of repeated short syllables. They differ between and within individuals. The fundamental frequency decreases in the trill part. There is no amplitude modulation in the trill part. Between two partners of a pair, the trill part is very distinct. One partner has a fast rhythm trill, and the other has a slower rhythm. This is likely to represent sexual dimorphism. Males probably have the fastest trill part. Bretagnolle distinguishes type A (fast rhythm trill) and Type B (slow rhythm) screaming calls. LSC are always much longer than DSC, usually twice as long and often higher in frequency.

Malacarne et al (1989) suggested that swifts are especially pronounced in sounds used in mate attraction and territorial advertisement (because they live in fairly simple and constant environments). The LSC probably has a territorial and/or agonistic function (Bretagnolle, 1993). Duet singing is thought to be relevant for pair bonding and territorial defence (Malacarne et al. 1991). According to Bretagnolle (1993) the DSC is individually distinctive and probably serves for individual or partner recognition and it probably also has a territorial function. The NC is given by a single bird, always when the pair is present and only given on the nest without eggs. It probably has a sexual function (mating/re-pairing for established pairs).

## 1.5 Problem definition

This study investigates the vocal behavior of the Common Swift (*Apus apus*) and the possibility to attract them to artificial nesting places. The study is split in two parts. The first part of the study deals with the vocal behavior of the Common Swift and the different calls they produce. This part of the study is of a descriptive nature. In order to understand in which way sound can be used to attract Common Swifts to artificial nesting places, it is important to understand the sounds produced by Common Swifts.
Field recordings were taken from several locations, both from individual birds and colonies. In the analysis, these recordings were compared to the outcome of previous studies, to see if the same calls can be identified and maybe new ones can be described.

The calls were divided in categories and specific characteristics were measured per category to find out if there were differences between individuals and between locations.

The second part of the study involves a set-up for playback experiments to explore the possible attraction of Common Swifts to playback of their sounds. Recordings of different sounds were used in a standardized way to investigate if birds react differently on the playback of different sounds. The vocal reactions were recorded and behavior was measured. In the analysis the different reactions to the different conditions and the vocal behavior of the birds to playback were described.

Central questions this study tries to answer are:

- What calls of the Common Swift can be identified?
- In what situations do the birds use these calls?
- Do calls differ between individuals?
- Do calls differ between locations?
- Do Common Swifts react to playback of their calls?
- Are Common Swifts attracted by playback of specific calls?

# 2. Method

## 2.1 Study area

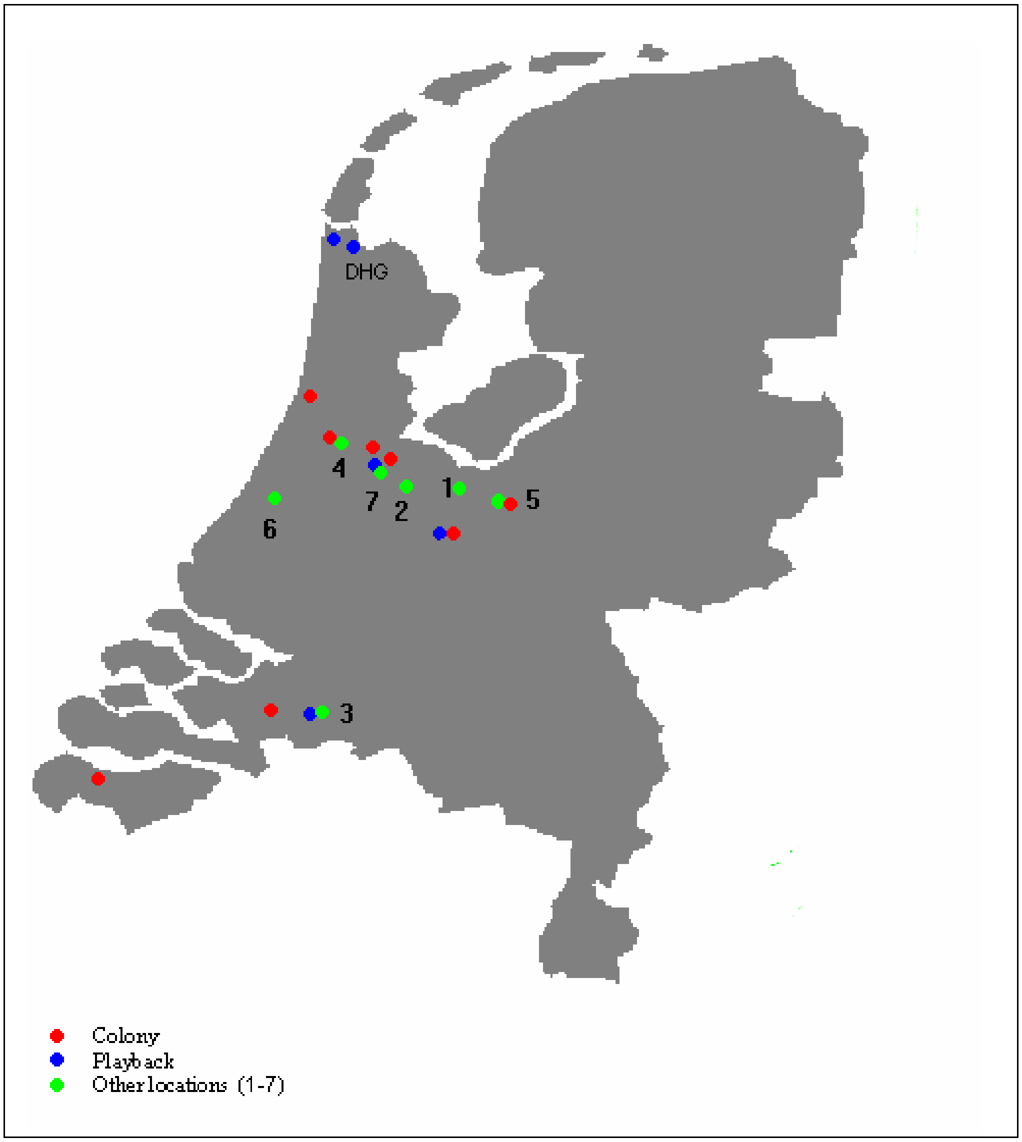



**Figure 2.1:** Map of recording and playback locations (1=Hilversum;2=Mijdrecht;3=Etten-Leur;4=Zaandam;5=Amersfoort;6=Leiden;7=Amstelveen; DHG=case study playback Den Helder)

In total a number of 20 locations were visited (see Figure 2.1) On 8 locations recordings were made of colony sounds of the Common Swift (red dots). The colony recordings were made at Common Swift colonies in urban area. Colonies consisted of several nests in one or more streets or in one building. On 7 other locations recordings were made (green dots). On these locations the concentrations of birds was not as high as in the colonies, so there was more chance to record the calls of individual birds. These recordings were made in backyards of people who had natural or artificial nesting places for Common Swifts. Sometimes a few nests were already occupied. On 5 locations playback experiments were performed (blue dots). The playback experiments were at locations with none or some occupied nests. Specific information per location (type of nests/colony, weather specifics, etcetera) can be found in Appendix I.

## 2.2 Audio recordings

***Date and time***

Recordings were made from June 16th until August 1st 2005.

Recordings were made in the morning between 07.30-13.00 h. or in the evening between 19.00-23.00 h. Recordings took place for approximately 1,5 hours (depending on several factors: weather, presence of birds, activity of birds).

Recordings were made on 15 different locations in total (see Figure 2.1). Of these 15, 8 locations were for the recording of colony sounds. The other 7 locations were locations with (artificial) nests of Common Swifts, (occupied as well as unoccupied; places where birds were known to fly round). The locations were distributed throughout the Netherlands (see Figure 2.1). Also 3 recordings were made of young birds fallen out of their nests and taken care of by humans.

***Recording equipment***

Recordings were made with a Sony tape-recorder TC-D5 ProII. Tapes used were TDK SA 90, High position IECII/Type II. Outside recordings were made with a Sennheiser M14 microphone, protected by a microphone windshield. The young birds were recorded with a Sennheiser ME64 microphone.

***Analysis***

Sounds were analyzed on a computer, with a SoundMax Digital Audio 5.10 soundcard. The analysis software was Avisoft SasLab Pro. Analogue tape recordings were digitized in the computer, from a JVC TDW708 cassette recorder into the Avisoft recorder. Calls were selected and normalized up to 75%. They were high-pass filtered at 1,5 kHz. The spectrograms were analyzed with a FFT-length of 256, in a FlatTop window.

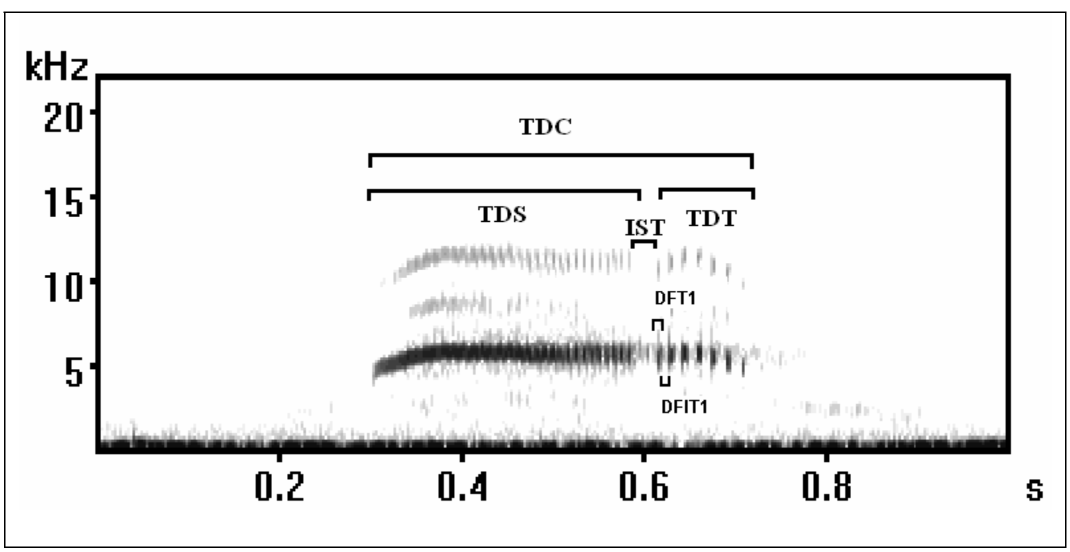



**Figure 2.2:** Temporal call parameters for calls of the Common Swift. Parameters are specified in Table 2.1

The calls of 6 (out of 7) locations were analyzed on several temporal (see Figure 2.2) and frequency parameters, as described in Table 2.1. The fundamental frequency is calculated by dividing the Peak Frequency Averaged over the Whole Call (PFAWC) by two, this represents the 2nd harmonic divided by two; it is therefore an approximation for the fundamental frequency (which can not be detected on the sonogram, see §1.4).

**Table 2.1:** Call parameters for calls of the Common Swift

| **Parameter** | **Full name** | **Measured in** |
|---|---|---|
| TDC | Total Duration Call | Seconds (s) |
| TDS | Total Duration Screaming part | Seconds (s) |
| TDT | Total Duration Trill part | Seconds (s) |
| IST | Interval between Screaming and Trill part | Seconds (s) |
| DFT1 | Duration First Trill | Seconds (s) |
| DFIT1 | Duration First Interval between Trill 1 and 2 | Seconds (s) |
| NT | Number of Trills | Number |
| PFAWC | Peak Frequency Averaged over Whole Call | Hertz (Hz) |
| PFTP | Peak Frequency Trill Part | Hertz (Hz) |
| PFF20ms | Peak Frequency First 20 ms (start frequency) | Hertz (Hz) |
| FF | Fundamental Frequency | Hertz (Hz) |

First distinguishable calls were identified on the basis of their sonograms. Calls were then divided in different categories. Calls with at trill part were divided in two groups based on their call duration (< 0.600 s. and ≥ 0.600 s.). Call without a trill part were considered as a different group and named 'peep calls'. Because some locations didn't have many recorded calls, a number of 10 calls per category were randomly selected for each location. In this way the number of calls was equal for each location.
For each call category the different parameters (Table 2.1) were measured and statistically tested in order to find out if there were individual or location differences. Individual differences were explored by taking 5 calls of one individual and comparing them to 5 calls of different individuals of the same location.
Location differences were compared using groups in One-Way ANOVA and Independent sample T-tests (normally distributed parameters) or Kruskal-Wallis H. and Mann Whitney U tests (not normally distributed parameters). The Bonferroni correction was used to explore which locations differed from each other. Statistical analyses were made with SPSS 12.0.1. A P-value of 0.05 was considered statistically significant.

## 2.3 Playback experiments

***Date and time***
Playback recordings took place for just over one hour, in the same morning-evening hours as the normal recordings. Colony and individual sounds of Common Swifts were chosen from the recordings to test to each other, with a period of no sound as a control period. Eight Playbacks were planned, randomly distributed over locations and time (morning/evening). A single playback experiment occupied 63 minutes in total, divided in three periods of 21 minutes. One period consisted 10 minutes observation before stimulus, 1-minute stimulus and 10 minutes observation after stimulus (see Figure 2.3). The stimulus part of the first and last period consisted of either individual or colonies

sounds; the second period was always the period with no sound as stimulus (control). At every playback location, different sounds (different locations, different morning/evening recordings) were used in different order (individual and colony sounds alternating for the first and last period). One-minute stimuli were created out of previous made recordings. For the individual stimulus, individual sounds (± 1 sec.) were isolated and repeated every 4 seconds (15 per minute). For the colony stimulus, colony sounds were isolated and played for 20 seconds, followed by 20 seconds of silence and repeated for another 20 seconds. All sounds were filtered below 2 kHz: low frequency noise was filtered out in this way. And sounds were amplified to their maximum.
The number of birds (in two different ranges from the speaker: 0-10 m; >10 m) was scored and their behavior was observed. Vocal responses were recorded.

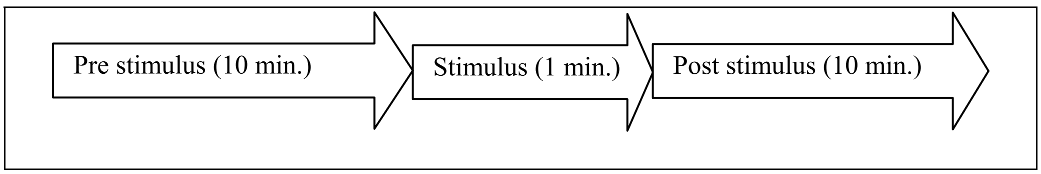



**Figure 2.3:** Schematic representation of one period of a playback experiment. One playback experiment consisted of three of these periods.

***Playback equipment***
Playbacks were broadcasted from an audio CD (Imation CD-R), from a Sony car radio CDX-S2000 (26W rms, frequency range 10-20000Hz, S/R relation of 120dB).
The loudspeaker used was a Visaton, type SC 4 ND (frequency range 1000-22000 Hz). The loudspeaker was placed on a standard and was approximately 2 meters high.
***Analysis***
In the playback analysis one location was used as a case study to explore the differences between the different stimuli (individual and colony sounds versus no sounds). Also the difference in number of scored birds before and after the stimulus was analyzed.

# 3. Results and Discussion

## 3.1 Inventory of calls

***Results***

On the basis of their sonograms (Box 1), different calls can be recognized. Screaming calls covered a broad range of durations (Total Duration of the Call 0.3308-0.8373 s. for the used sample). Figure A in Box 1 shows a sonogram for a screaming call. The screaming part and trill part are divided by a silent interval. The trill part often decreases in frequency. The Peak Frequency Averaged over the Whole Call (PFAWC) in the sample lies between 4470-6710 Hz., the Fundamental Frequency (FF) therefore between 2235-3355 Hz.

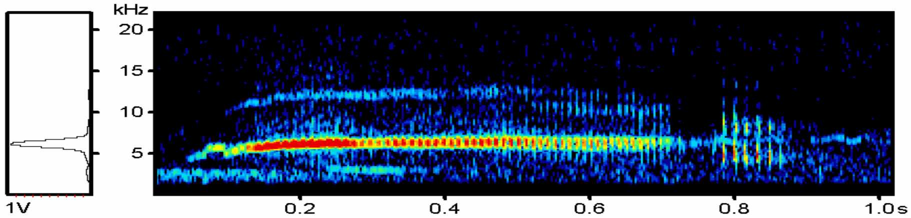
Figure B in Box 1 shows calls given in duet of two Common Swifts. Duet calls sometimes overlap each other. There are not enough recordings of calls given in duet to use for further analysis. Because of overlap and other individuals screaming during these calls, it is difficult to analyze them.

The clear distinction Bretagnolle made between Long Screaming Calls and Duet Screaming Calls based on call duration couldn’t be reproduced in this study. The reason and following implications for the rest of the analysis are given in the discussion.

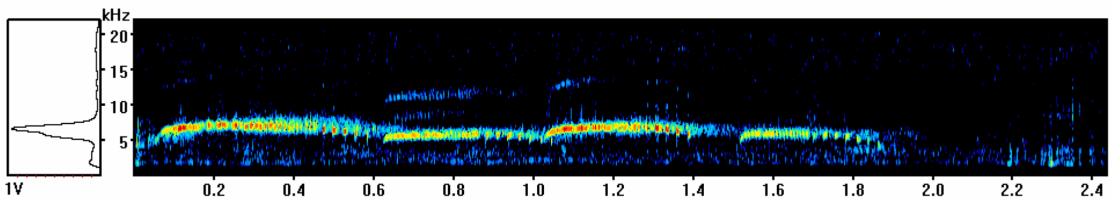
Calls were found that didn’t contain a trill part. These calls are named ‘peep’ calls (Box 1; C), because they are usually short calls that sound like peeps. Because they lack a trill part, only four parameters can be used for further analysis: TDC, PFAWC, PFF20ms and FF (see Table 2.1). Peep calls are given before screaming calls as well as independently. They are given once or repeatedly. The PFAWC for peep calls lies in the sample between 3960-6200 Hz; FF between 1980-3100 Hz. Their TDC’s are given in the range of 0.0507-0.2873 s.

Recordings of young birds also provided sonograms. In Box 1, Figures D and E, the sonograms of one individual young bird, at the age of 33 and later 45 days are shown. The fundamental frequency of the young birds seems to correspond to that of older birds. These calls were not used in further analysis.

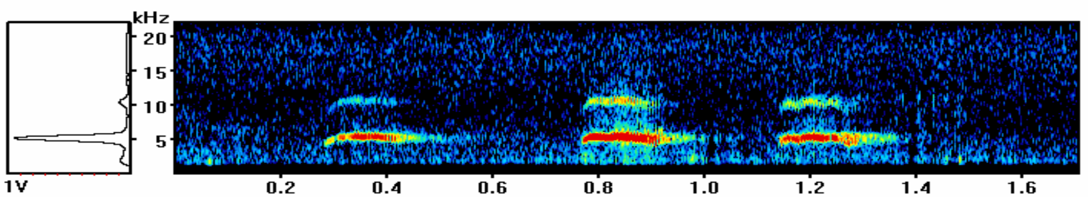
**Box 1:** Sonograms of different Common Swift calls.



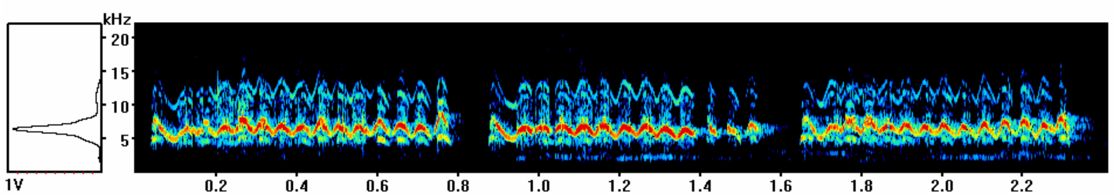
A. Sonogram screaming call



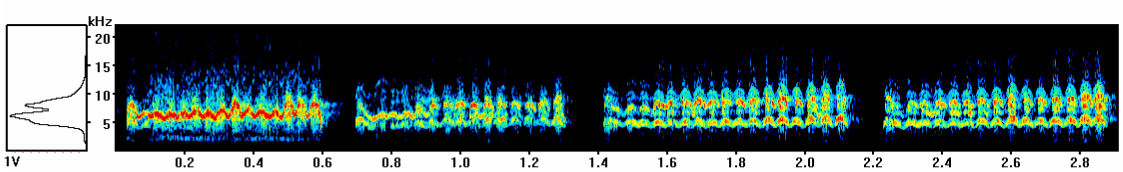
B. Sonogram screaming calls given in duet



C. Sonogram Peep calls



D: Sonogram young bird at age 33 days



E: Sonogram young bird at age 45 days

### *Discussion*

We tried to follow Bretagnolle‘s classification of calls but the distinction between Long Screaming Calls and Duet Screaming Calls proved problematic. Bretagnolle only mentioned that LSC were approximately twice as long as DSC but didn’t describe a specific method to tell the two apart. Our results do not confirm his statement of LSC’s being twice as long as DSC’s (see also §3.3).
A meaningful distinction between these calls may be their difference in context of behavior (e.g. territorial behavior/partner recognition) and environment (e.g. in the air/on the nest). But the definition of a DSC, formulated by Bretagnolle as given in duet or not is not consistent. If calls are given only in duet, they can be described as duet-calls. Single calls need to be investigated further to explore differences in other parameters in order to identify them as separate entities. This is difficult and time-consuming research.

- When swifts are giving calls, they usually react very rapidly to calls of others and screams are given at the same time. It is virtually impossible to analyze calls if there are many individuals screaming together, because their frequencies overlap each other.
- When the birds are flying, it is very difficult to tell them apart and to know which bird is calling. We did not mark the birds individually, following the preference of GBN, to disturb the birds as little as possible. Therefore the context of every individual call is hard to define.
- Also when calls are given in duet, it is usually from the nesting place when the pair cannot be seen.

One possibility to address these problems is to combine recordings of video cameras with sound recordings. However, when recorded in the nesting place, sounds are often distorted, because of the limited space. In addition, the problem of individual recognition (to the observer) needs to be solved and it is hardly possible to do so without marking individuals.

## 3.2 Individual differences

***Results***

Few repeated measures of calls of individuals were made, because the recordings were mostly made during flight and it was very difficult to distinguish individuals in the air. In recordings where an individual could be followed, it only uttered one or two calls in a row, which is not enough for statistical testing. Therefore it was very difficult to explore differences within and between individuals in a statistical manner.
On one location, Amersfoort, we recorded one individual calling 5 times in a row from a nest box. The calls of this bird were used as a case study to investigate the differences within one individual (Table 3.1 compared to other individuals (Table 3.2).

**Table 3.1:** Call parameters of 5 different calls of a single individual calling from the nest in Amersfoort

| **Nr.** | **TDC** | **TDS** | **TDT** | **IST** | **DFT1** | **DFIT 1** | **NT** | **PF AW C** | **PF TP** | **PF F20ms** | **FF** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | 0.5035 | 0.3555 | 0.1335 | 0.0145 | 0.0072 | 0.0145 | 6 | 6020 | 5850 | 4300 | 3010 |
| **2** | 0.4643 | 0.3337 | 0.1219 | 0.0087 | 0.0101 | 0.0116 | 6 | 6200 | 5850 | 4300 | 3100 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **3** | 0.4542 | 0.3236 | 0.1219 | 0.0087 | 0.0101 | 0.0101 | 6 | 6540 | 6200 | 6890 | 3270 |
| **4** | 0.3671 | 0.2191 | 0.1364 | 0.0116 | 0.0145 | 0.0116 | 6 | 6020 | 5850 | 4820 | 3010 |
| **5** | 0.4600 | 0.3395 | 0.1131 | 0.0074 | 0.0101 | 0.0130 | 5 | 6020 | 5850 | 4300 | 3010 |
| | | | | | | | | | | | |
| **AV** | 0.4498 | 0.3143 | 0.1254 | 0.0102 | 0.0104 | 0.0122 | 5.8 | 6160 | 5920 | 4922 | 3080 |
| **SD** | 0.0501 | 0.0544 | 0.0095 | 0.0029 | 0.0026 | 0.0017 | 0.45 | 226.3 | 156.5 | 1123.0 | 113.1 |

**Table 3.2:** Call parameters of 5 different calls given by individuals in the air in Amersfoort

| Nr. | TDC | TDS | TDT | IST | DFT1 | DFIT1 | NT | PF AWC | PF TP | PF F20ms | FF |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | 0.5979 | 0.4237 | 0.1349 | 0.0393 | 0.0087 | 0.0130 | 7 | 6200 | 5850 | 4470 | 3100 |
| **2** | 0.4426 | 0.2568 | 0.1814 | 0.0044 | 0.0101 | 0.0116 | 8 | 5680 | 5680 | 4300 | 2840 |
| **3** | 0.5253 | 0.3468 | 0.1146 | 0.0639 | 0.0058 | 0.0072 | 9 | 5340 | 5160 | 5680 | 2670 |
| **4** | 0.4266 | 0.2844 | 0.1306 | 0.0116 | 0.0072 | 0.0159 | 5 | 6370 | 5680 | 5850 | 3185 |
| **5** | 0.4934 | 0.3033 | 0.1843 | 0.0058 | 0.0058 | 0.0174 | 9 | 5160 | 5160 | 4990 | 2580 |
| | | | | | | | | | | | |
| **AV** | 0.4972 | 0.3230 | 0.1492 | 0.0250 | 0.0075 | 0.0130 | 7.6 | 5750 | 5506 | 5058 | 2875 |
| **SD** | 0.0688 | 0.0651 | 0.0317 | 0.0259 | 0.0019 | 0.0039 | 1.67 | 526.3 | 323.4 | 696.3 | 263.2 |

To explore the variation within the individual compared to the variation between individuals, the 5 calls of the individual were compared to 5 other calls of the same location. These calls were presumably of different individuals, but this cannot be concluded for sure. The example is not meant for any statistical analysis, but just to serve as an indication of variation within and between individuals. The five other calls were randomly chosen from the location recordings. These calls were chosen with a duration shorter than 0.6 s. because the calls of the individual were also shorter than 0.6 s.

In Figure 3.1 the data for the Total Duration of the Call (TDC) are shown in box plots. Group 1 are the calls of the individual, group 2 are the other selected calls of the location. The averages of both groups show little difference (0.1254 for group 1; 0.1492 for group 2; Table 3.1 + 3.2). The variation of group 1 is low compared to the variation of group 2 (St. Dev. 0.0095 group1; 0.0317 group 2). All other parameters show a similar pattern.

## *Discussion*

Five calls of one individual, compared to five calls of presumably different individuals, show that intra-individual variation is low compared to inter-individual variation.

It seems logical for a species that (to us) is monomorphic and spends most of its time in the air, that the voice and calls are very important in communicating and recognizing each other. Previous studies propose that the difference between individuals can be found in the trill part. As in these previous studies (Malacarne et al. 1989; Bretagnolle 1993) the sample size in this study is too small to conclude anything about how these trill parts differ between individuals and if males and females have different ones. When comparing different locations (see §3.3) one trill parameter differs significantly between the locations. More research is needed to conclude if these differences are caused by location, individual or other factors.

Differences between individuals can have consequences for the playback of calls. If there are distinct differences between individuals, then playback sounds should be used of different individuals, so birds cannot get used to a specific sound. If there are no distinct differences between individuals, in theory it should not matter how many individuals are used in playback. It is however always better to use calls of different individuals, for reasons of habituation and also because not all possible call parameters are measured: there could be differences in other call characteristics. The geographical distribution (i.e. difference in location) should be taken into consideration. Individual variation can be affected by location, and therefore important in playback experiments.

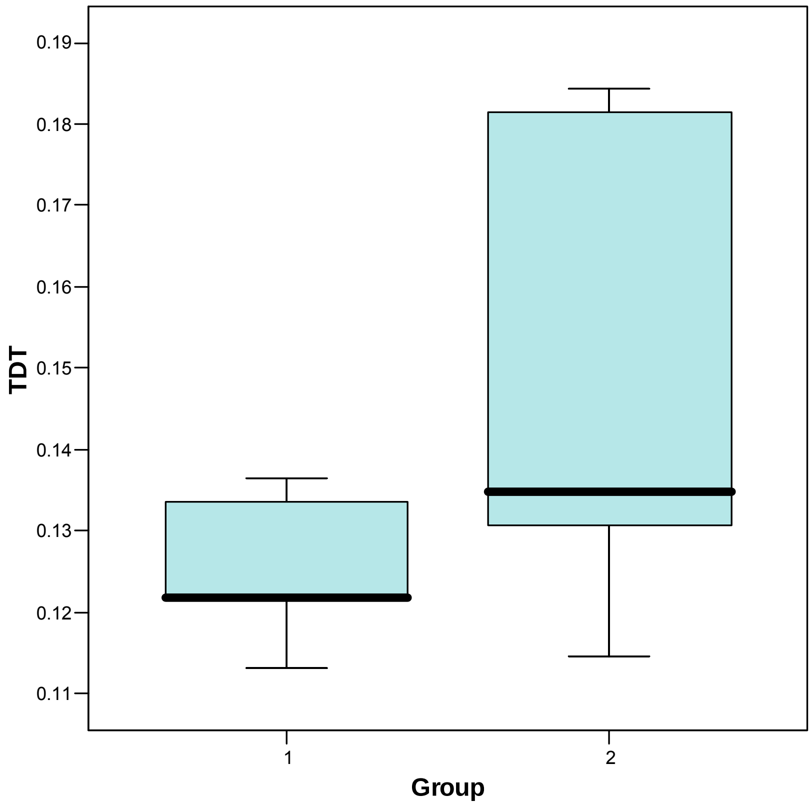



***Figure 3.1:*** *Box plots for Total Duration of the Trill part for 5 calls of a single individual (Group 1) and 5 calls of different individuals (Group 2) in Amersfoort*

## 3.3 Location differences

***Results***

Of the seven recording locations, enough calls (n>8) were recorded for further analysis on 6 locations. On the 7$^{th}$ location (Amstelveen, see Figure 2.1), only 4 calls were recorded.

Bretagnolle made a distinction between Long Screaming Calls and Duet Screaming Calls based on the duration of their calls. To explore the range of call duration of the screaming calls in this sample, a frequency distribution (Figure 3.2) was made in which the Total Duration of the Call is set out against the frequency of the calls (number of time certain calls are observed). There is a peak around 0.400/0.4500 s. and there is a second peak around 0.6500/0.700 s. Therefore two groups were made: < 0.600 s. (short calls) and ≥ 0.600 s. (long calls). The analyses were done in two ways: all calls grouped together (analysis 1) and the calls split in two groups (analysis 2).

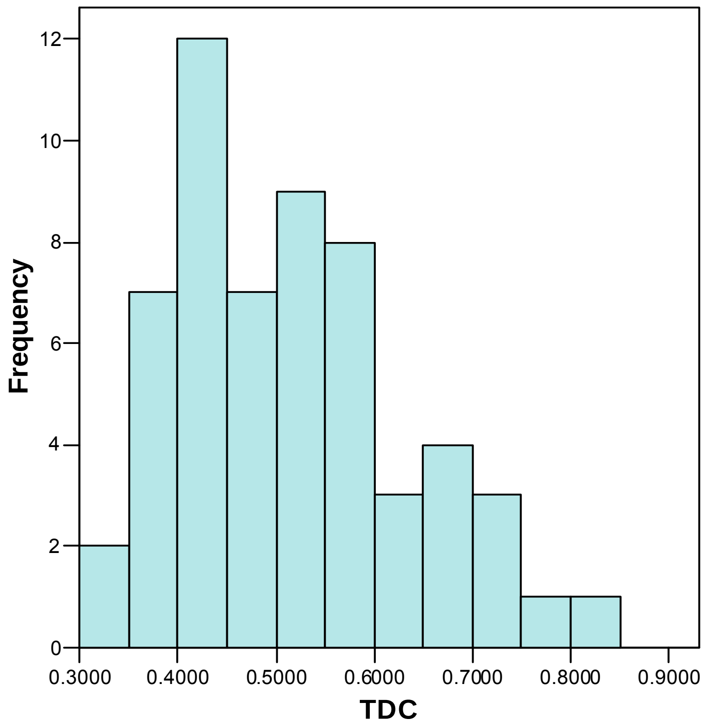



**Figure 3.2:** Frequency distribution of the Total Duration of the Call for all measured calls on 6 locations

***Analysis 1: All calls grouped together***

When calls were grouped together, 4 of the 11 measured parameters were significantly different between the 6 locations (compare Table 2.1 with Table 3.3). In Figure 3.3 the parameter Total Duration of the Call is shown as an example of one of the 4 significant parameters. The figure shows that the averages for the TDC for the 6 locations (numbered as in Figure 2.1) do not differ very much from each other. In this example, location 3 and location 6 are significantly different (P = 0.033). The other significant parameters for the calls grouped together are the Interval between Screaming part and trill part (IST), the Duration First Interval between Trill 1 and 2 (DFIT1: trill 1 and 2 means between the first two syllables of the trill part) and the Peak Frequency of the First 20 ms. (PFF20ms: start frequency). The P-values of these significant parameters are given in Table 3.3.

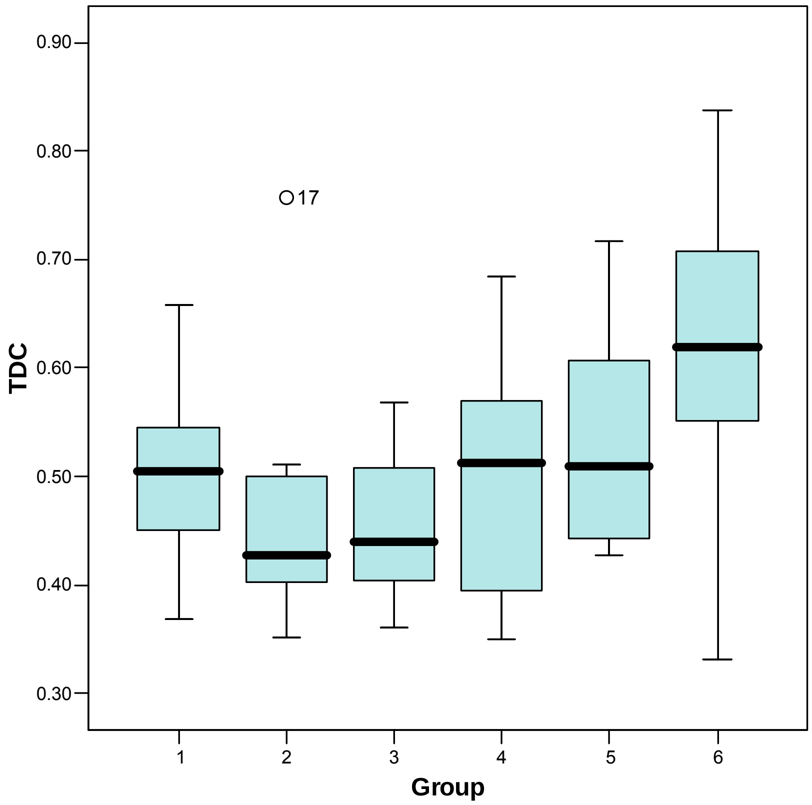



**Figure 3.3:** Box plots for the Total Duration of the Call for the 6 locations, calls grouped together

**Table 3.3:** Statistical differences of significant call parameters between locations when all calls are grouped together

| Parameter | P-value* | Locations |
|---|---|---|
| TDC | 0.033 | 3,6 |
| IST | 0.019 | - |
| DFIT1 | 0.006 | 1,2 |
| PFF20ms | 0.035 | - |

*Tests used: One-way ANOVA and Kruskal-Wallis H

**Table 3.4:** Statistical differences of significant call parameters between locations for calls < 0.600 s.

| Parameter | P-value* | Locations |
|---|---|---|
| IST | 0.048 | - |
| DFIT1 | 0.002 | 1,2 and 1,4 |

*Tests used: One-way ANOVA and Kruskal-Wallis H

***Analysis 2: Calls split by call duration***

When the calls are split in two groups (< 0.600 s. and ≥ 0.600 s.), two parameters showed significant differences between locations for the group < 0.600 s. The P-values are given in Table 3.4. For the group ≥ 0.600 s., two locations had enough calls tot test statistically.

None of the 11 call parameters (see Table 2.1) were found to differ significantly between the two locations Amersfoort and Leiden (see Figure 2.1).

***Peep calls***

Peep calls (calls without a trill part) were treated as a different group (see §3.1). Ten peep calls of each location were compared. For peep calls only 4 parameters were taken, because the calls do not contain a trill part. All parameters were found to significantly differ between the 6 locations. P-values of these parameters are given in Table 3.5.

**Table 3.5:** Statistical differences of significant call parameters between locations for peep calls

| Parameter | P-value* | Locations |
|---|---|---|
| TDC | 0.007 | 4,5 |
| PFAWC | 0.004 | - |
| PFF20ms | 0.002 | All groups with 2 |
| FF | 0.004 | - |

*Tests used: One-way ANOVA and Kruskal-Wallis H

## Discussion

The parameters that are significantly different for both analyses are the interval between the screaming and the trill part (IST) en the interval between the first two syllables of the trill part (DFIT1). The parameters that are only significantly different when the calls are grouped together are the total duration of the call (TDC) en the start frequency (PFF20ms). So when the groups are split by call duration, TDC is no longer significantly different (so maybe there are indeed different groups categorized by call duration, like Bretagnolle suggested). Why the start frequency is no longer significant is not clear.
It seems there are differences in calls between locations, but not for all call parameters. Because of the small sample size, especially of repeated recordings from single individuals, it cannot be concluded whether these differences are really caused by location-bound factors or rather by individual or other factors. There was no specific pattern in which locations differed from each other, for all parameters this was different. More research is needed to explore what factors underlie geographic differences. Differences in call could result from environmental differences between locations or from geographic (reproductive/genetic) isolation between populations of the species. In addition, song learning could contribute to geographic variation, it is not known whether Common Swifts learn their call (it is known in the order of Apodiformes, but not in the family of Apodidae). The Common Swift has been described as highly philopatric and always returning to the same breeding area. It has been suggested that extreme philopatry can cause macro- and microscale geographic variations in calls (Bretagnolle and Genevois, 1997).
Unfortunately, the data of this study cannot be compared properly with the previous data from Bretagnolle (1993). The dividing of the calls based on their call duration was an attempt to allow comparisons between the two studies, but the difference in approach makes it questionable to do so. Based on raw data, there doesn’t seems to be much difference between for example the peak frequency averaged over the whole call for all calls (±5000-6000 Hz study Bretagnolle, 4470-6710 Hz this study), and the fundamental frequency (around 2500 Hz Bretagnolle, 2235-3355 Hz this study). Neither do these

parameters give rise to any significant differences in this study (and the data cannot be statistically tested). It is interesting to note that the variation of the raw data is smaller for this study than in the study of Bretagnolle, although his study has a larger sample size. How this is caused is unclear. More research on more parameters is needed to explore the possible geographic variation of the calls of the Common Swift.
Differences between locations can also have impact on the playback of calls. If there are differences between different locations, then perhaps on every location the calls from that area should be used. If there are no differences between locations, it should not matter.

## 3.4 Playback experiments

***Results***
Five of the eight planned playbacks were performed, due to the weather and the short field-period. Of these five playbacks, only one was used for analysis. On the other locations there were either not enough or no birds at all to test reactions. Therefore, the playback that took place in Den Helder (see Figure 2.1) will be treated as a case study.

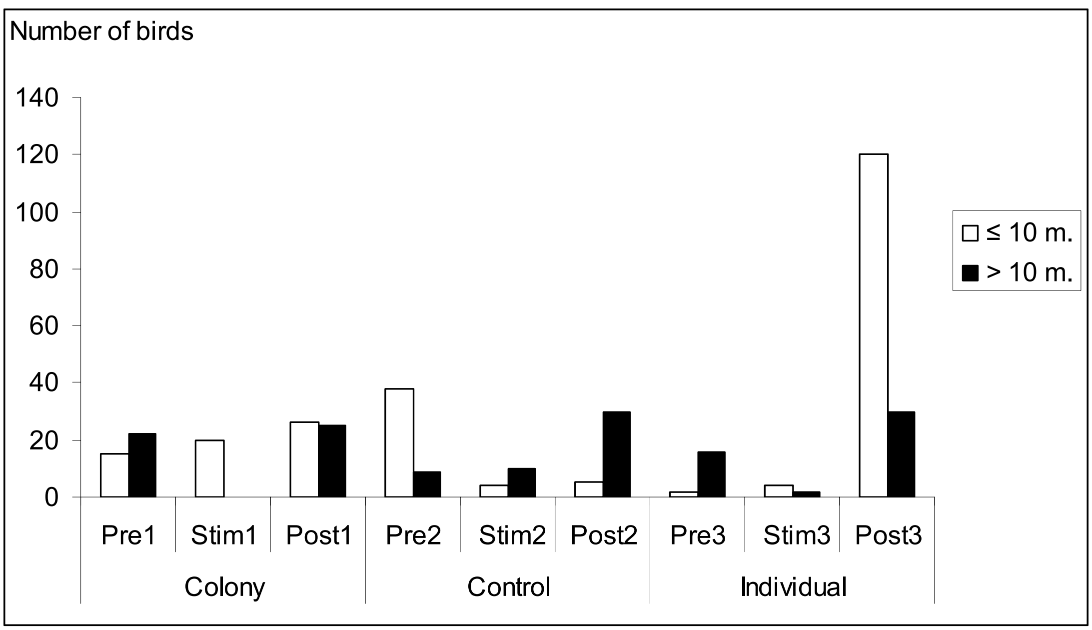



**Figure 3.4:** Number of birds scored during a playback experiment in Den Helder (DHG)

In Figure 3.4 the number of birds that were scored during the playback experiment in Den Helder is given. The playback experiment took place in the morning. The first period had a colony sound during the stimulus, the second period was the control period (no sound) and the third period had an individual sound during the stimulus. Swifts were scored within a range of 10 meters and outside a range of 10 meters of the speaker.
The number of birds within a range of 10 meters of the speaker is increasing in the first period of the experiment (colony sound stimulus). Before the stimulus 15 birds were scored, during the stimulus 20 birds and after the stimulus 26 birds (it is important to notice that the pre and post phases are 10 minutes long and the stimulus period just 1

minute, so 15 and 20 birds maybe seem not that different, but it is a much shorter time period). During the second period (control, no sound) the number of birds within the range of 10 metres is decreasing. In the pre2 phase there were 38 birds scored, maybe this is still due to the effect of the colony stimulus of the first period. In the stim2 and post2 phase only 4 and 5 birds were scored. In the third period of the experiment (individual sound stimulus) the number of birds within a range of 10 metres is increasing. During pre3 there were 2 birds scored, during stim3, 4 birds were scored and during post3, a number of 120 birds were scored.

The number of birds scored outside the range of 10 meters in the first period is almost the same for the pre1 and post1 phase (22 and 25 birds). During Stim1 no birds were scored outside. During the second period the number of birds outside 10 meters was increasing; pre2: 9 birds, stim2: 10 birds, post2: 30 birds. During the third period 16 birds were scored during pre3, 2 during stim2 and 30 during post3.

In total there were for period 1: 37 birds before and 51 birds after the stimulus; for period 2: 47 before and 35 after; period 3: 18 before and 150 after.

Some general observations in the field were that swifts flew around the speaker from which the sounds were played back. One bird tried to visit the speaker during by trying to hang on to it. Birds gave vocal responses both on colony as on individual sounds. It was too difficult to analyse these vocal responses, because they overlapped the stimuli sounds and because several reacting birds were calling at the same time.

## *Discussion*

The playback experiments is this study were performed at the end of the breeding season. In most cases, there were not enough birds present to score reactions. The case study of Den Helder (see 3.4) shows that the number of birds scored within a range of 10 meters from the speaker increases during both the stimuli periods of colony and individual sounds and that it decreases during the control period. For the period around the colony sound stimulus there is a difference between scored birds before and after playback, but it is not a large number (15 to 26). Before and after the control stimulus the numbers of scored birds differ more (38 to 5). The large number of birds before the second stimulus is maybe still due to an effect of the first period (colony sounds). The difference between before and after playback for the third period with individual sounds is the most striking: 2 to 120. Here it seems there is an effect of the playback of individual sounds to the number of birds present within a range of 10 meters from the speaker. The birds scored outside the range of 10 meters don’t show a similar pattern (period 1: same before and after playback, period 2 increasing, period 3 decreasing). Maybe the influence of the playback was not over a wide area, or maybe it is just caused by birds flying in and out of the range of 10 meters.
This case study has not enough data about the possible effects of playback of sounds on the attraction of Common Swifts to artificial nesting places. However, the data we do have suggest there could be an effect of the playback of individual sounds. More experiments are needed, not only with individual sounds but also with colony sounds to collect enough data for statistical testing. These experiments should cover the whole

breeding season, because maybe there is a difference in reaction during the season (at the beginning of the season birds could be looking for nests for the current year, at the end of the season they maybe look for places for the following year).

Playback experiments, performed as in this study, don't tell us anything about the influence on the long-term reactions of the birds of these playbacks. Possible short-term attraction of birds to speakers or artificial nesting places doesn't guarantee the permanent nesting and breeding of the birds. Therefore any further playback experiments need to be followed by a longer period of monitoring the birds at the artificial nesting places to see if playback not only can enhance attraction of the birds but also long-term breeding.

# 4. Conclusions and Recommendations

Different Common Swift calls have been described, but not similar to the categorization of calls as Bretagnolle (1993) formulated. His inventory did not match our findings. There are calls with and without a trill part, over a broad range of call durations. Maybe a more meaningful distinction between calls is their difference in context of their behavior and the environment. Further research should take this context in consideration when exploring the different calls of the Common Swift. This pilot research met with many difficulties, of which the problem of individual recognition is the largest handicap in Common Swift research. This problem can probably only be addressed by marking individuals. Another problem is that sounds at the nesting place can’t be adequately recorded due to echo effects of the walls. Nest boxes lined with sound absorbing materials might mitigate these problems.

It seems that intra-individual variation is low compared to inter-individual variation. Significant differences between locations are found for some call parameters, but it is not clear what factors underlie these geographical differences. More research, especially on single individuals is needed to explore to what the differences between some call parameters are caused by individual or location differences. With more data, also more different calls might be identified and understood.

Common Swifts do seem to react on the playback of their calls, both behaviorally and vocally. Playback of individual sounds show some indication for attracting Common Swifts, but more experiments with both individual and colony sounds are needed for statistical testing.

Only intensive further research can help us understand to what extent playback of calls of the Common Swift can attract them to artificial nesting places and if there are specific calls that can attract the birds more efficiently. Further experiments need to be done during the whole breeding season. A longer period of monitoring the birds is needed to explore the possible long-term effects of call playback and the possible settlement of Common Swifts in artificial nesting places.

***Recommendations***

- A follow up to this research, covering more seasons and yielding more data
- Geographical differences need to be explored
- This research should include suitable methods for individual recognition and make use of a combination of video and sound recording
- In order to make reliable sound records in the nesting place, experiments with nest boxes lined with sound absorbing materials should be considered
- After such a follow up, GBN has to agree upon a suitable monitoring method and implement it at a number of locations

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# Dankwoord

Hierbij wil ik iedereen bedanken die heeft meegeholpen aan dit project.
Mijn begeleiders in Leiden Prof.dr. Carel J. ten Cate en Dr. Hans Slabbekoorn voor de wetenschappelijke begeleiding, ondersteuning en correcties. Mijn begeleider in Groningen Dr. Maureen E. Butter, voor aansturing, adviezen en correcties.
De vakgroep Gedragsbiologie in Leiden voor de stimulerende bijeenkomsten en hulp in het Bioacoustic Lab.
Alle vrijwilligers van GierzwaluwBescherming Nederland die mij hartelijk in hun huizen en tuinen hebben ontvangen: Familie Born in Amstelveen; Joost Huijsing in Hilversum; Angeniet Kam in Haarlem; Antoon Koenraadt in StanddaarBuiten; Rita Lukkien in Den Helder; Arie Noteboom in Mijdrecht; Gery Posch in Den Helder; Els van der Pol en Jan Visser in Zaandam; Floris Wouterlood in Leiden. Speciale dank gaat uit naar de bestuursleden van GierzwaluwBescherming Nederland: Marleen Andriessen, Fred en Marjo van der Lelie, Fred van Vliet en Rick Wortelboer.
Mijn broer voor de hulp bij het ontwerpen van de voorkant.
En mijn derde corrector, dank je wel voor al je nuttige commentaar, je vertrouwen en je liefde.

Appendix

**Recording specifics for recordings used in analyses**

| ***Date*** | **Code** | **Location** | **Time (h)** | **Weather (±)** | **Recording** | **Details** |
|---|---|---|---|---|---|---|
| 26/06/05 | EL | Etten-Leur | 16.30-20.30 | 20°C<br>W?<br>sunny | E | - house without nests but with possibility to nests, swifts are known to fly around |
| 28/06/05 | AK1, AK2 | Amstelveen Kol | 20.00-22.15 | 20°C<br>W 3-4<br>sunny | COL E | - AK1: ± 30-40 nest boxes (stone) in walls of houses (8 x 7 boxes)<br>- AK2: street with ± 30 nests under bovenste boegboord |
| 29/06/05 | M | Mijdrecht | 09.30-15.00 | 21°C-24°C,<br>W 3-4<br>cloudy, later sunny | M+ | - house with 15 nest tiles<br>- 1 occupied<br>- 2 cameras<br>- lot of traffic noise/ airplanes |
| 01/07/05 | AMF | Amersfoort L | 20.00-22.00 | 20°C<br>W 2<br>Small clouds high up | E | - house with ± 6 nest boxes (stone/wood)<br>- ± 2 occupied<br>- 2 cameras<br>- noise of other birds, no traffic noise |
| 04/07/05 | HI | Hilversum | 08.00-11.00 | 19°C<br>W 4<br>Heavily clouded | M | - house with 4 nestboxes (wooden)<br>- 1-2 occupied<br>- no noise |
| 05/07/05 | Z | Zaandam | 19.30-22.00 | 20°C<br>W 3<br>clear sky | E | - house with 1-2 nests<br>- 1 camera<br>- not much noise |
| 07/07/05 | AMF KOL | Amersfoort Kol | 09.00-10.30 | 21°C<br>W?<br>sunny | COL M | - 10-15 natural nests under roof of hotel<br>- traffic noise |

| | | | | | | |
|---|---|---|---|---|---|---|
| 10/07/05 | GR | Groede | 10.00-11.00 | 24°C<br>W 3-4<br>sunny | COL M | - ± 15-20 natural nests under the roof of a church<br>- no noise |
| 11/07/05 | AK1 | Amstelveen Kol | 20.00-21.15 | 20°C<br>W 4-5<br>heavily clouded | COL E | - see above |
| 12/07/05 | AB | Amstelveen B | 08.30-12.00 | 21°C<br>W?<br>cloudy | M | - house with 1-2 natural nests under tiles<br>- 1 camera<br>- some noise of airplanes |
| 12/07/05 | ZRB | Zaandam Kol | 20.30-22.15 | 20°C<br>W 3<br>clear sky<br>windy | COL E | - several natural nests under roofs of houses in one street<br>- no noise |
| 14/07/05 | U | Utrecht | 10.00-11.30 | 25°C<br>W 3-4<br>sunny | COL M | - ± 30 natural nests under roofs of houses in one street<br>- traffic noise |
| 14/07/05 | HA | Haarlem | 20.00-22.00 | 24-25°C<br>W 2<br>clear sky | COL E | - ± 20 nests in 10 houses in one street<br>- no noise |
| 17/07/05 | SB | Stand Buiten | 10.00-12.00 | 24-25°C<br>W 2-3<br>sunny | COL M | - 30 nest tiles and 20 nest boxes placed on one single house<br>- 1 camera<br>- no noise |
| 18/07/05 | L | Leiden | 09.00-11.00 | 23-24°C<br>W 3-4<br>sunny | M | - 2 nestplaces naast dakkapel: not known if occupied, probably both<br>- 1 camera<br>- no traffic noise<br>- noise from gulls and blackbirds |
| 23/07/05 | AB | Amstelveen B | 20.00-22.00 | 20°C | PLB E | - see above |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | W?<br>clear sky<br>sunny | | |
| 24/07/05 | DHG | Den Helder G | 09.00-12.00 | 21°C<br>W 3<br>sunny/cloudy | PLB M | - 4 nestboxes (stone), 1 occupied<br>- 6 empty nest tiles<br>- 1 camera<br>- no noise |
| 26/07/05 | DHR | Den Helder R | 09.00-12.00 | 19/20°C<br>W 4-5<br>cloudy/ rainy | PLB M | - 5 nest boxes (stone), 1 occupied<br>- 3 nest boxes neighbours<br>- 1 camera<br>- no traffic noise, noise of other birds |
| 29/07/05 | U | Utrecht | 10.30-13.00 | 25°C<br>W 3-4<br>sunny/hot | PLB M | - see above<br>- recordings without windshield |
| 30/07/05 | EL | Etten-Leur | 10.00-12.00 | 23-24°C<br>W 5-6<br>sunny/cloudy/<br>windy | PLB M | - see above |
| **Extra** | | | | | | |
| 28/06/05 | AM | Amstelveen M | 20.00- 20.30 | Indoors | YB E | - 1 young bird fallen out of a nests and raised by humans (32/33 days old) |
| 11/07/05 | AM | Amstelveen M | | Indoors | YB E | - 1 young bird fallen out of a nests and raised by humans (40-45 days old) |

COL = Colony recording
E = Evening recording
M = Morning recording

PLB = Playback experiment
YB = Recording Young Bird
W = Wind speed in Beaufort